

[0001] This application claims the benefit of and priority to copending German Patent Application No. 10037728.9, filed at the German Patent Office on August 2, 2000, entitled “Light Running Shoe,” the entire disclosure of which is hereby incorporated herein by reference.

[0002] The invention generally relates to a light weight sole, article of footwear, and method of manufacture. More specifically, the invention relates to a sole and article of footwear having a mesh layer at least partially embedded in a sole layer, and methods of manufacture.

[0003] Soles of conventional athletic shoes such as running shoes, are characterized by layered structures which typically consist of an outer sole, a mid sole, and an inner sole. The outer sole conventionally consists of a non-abrasive, low-elastic material or rubber which is characterized by a relatively high density and therefore also by a relatively high weight. The outer sole significantly contributes to the weight of the shoe, which causes the wearer to tire quickly, especially in competition situations. The conventionally used mid sole also contributes significantly to the weight of the sole and the resulting shoe.

[0004] The sole and article of footwear of the present invention overcome the problem of high weight in known soles and articles of footwear. The invention generally relates to a light weight sole that avoids the use of a conventional, heavy outsole, without sacrificing traction and damping. Since conventional outsoles have a relatively high weight, the total weight of the sole is significantly reduced. According to the invention, the sole is constructed from a light weight rigid or semi-rigid polymeric layer having a mesh or fibers at least partially embedded in the layer. The mesh can be substantially embedded or coterminous with the polymeric sole layer. The mesh provides traction for the wearer and abrasion resistance for the sole. Profile depressions can be formed in the sole layer to further provide traction for the wearer.

[0005] In one aspect, the invention relates to a sole for an article of footwear. The sole includes a sole layer and a mesh layer at least partially embedded in the sole layer. The mesh layer can have a contoured surface including a knit structure formed from one or more threads. The one or more threads can include spun fibers. The threads can be constructed from one or more metals, polyesters, polyamides, aramids, and combinations of these materials. The mesh layer can extend beyond a bottom ground engaging surface of the sole layer or can be substantially coterminus with the bottom surface of the sole layer. The sole layer can include one or more profile grooves defined by the bottom surface of the sole layer. The sole layer can include a damping material including ethylene vinyl acetate, polyurethane, rubber, and combinations of these materials.

[0006] In another aspect, the invention relates to an article of footwear. The article of footwear includes an upper, a sole layer attached to the upper, and a mesh layer at least partially embedded in the sole layer. The mesh layer can have a contoured surface including a knit structure formed from one or more threads. The one or more threads can include spun fibers. The threads can be constructed from one or more metals, polyesters, polyamides, aramids, and combinations of these materials.

[0007] In various embodiments, the mesh layer can extend beyond a bottom ground engaging surface of the sole layer or can be substantially coterminus with the bottom surface of the sole layer. The sole layer can include one or more profile grooves defined by the bottom surface of the sole layer. The sole layer can include a damping material including ethylene vinyl acetate, polyurethane, rubber, and combinations of these materials.

[0008] In yet another aspect, the invention relates to a method for manufacturing a sole for an article of footwear. The method includes the steps of providing a mold, inserting a mesh into the mold, and forming a sole layer in the mold, the sole layer having the mesh layer at least partially embedded in the sole layer. The method can include the step of mounting the mesh to an inner surface of the mold. The mold can have an inner surface structure complementary to that of the mesh. Alternatively or additionally, the inner surface structure can form one or more profile grooves in the bottom surface of the sole layer formed therein. The sole layer can be formed so that the mesh extends beyond a bottom surface of the sole layer or is substantially coterminus with the bottom surface of the sole layer. The sole layer can be formed by injection molding, compression molding, or other suitable method.

[0009] In still yet another aspect, the invention relates to a method for manufacturing an article of footwear. The method includes the steps of providing a mold, inserting a mesh into the mold, and forming a sole layer in the mold, the sole layer having the mesh layer at least partially embedded in the sole layer. The method also includes attaching an upper to the sole layer. The method can include the step of applying the mesh to an inner surface of the mold. The mold can have an inner surface structure complementary to that of the mesh. Alternatively or additionally, the inner surface structure can form one or more profile grooves in the bottom surface of the sole layer formed therein. The sole layer can be formed so that the mesh extends beyond a bottom surface of the sole layer or is substantially coterminous with the bottom surface of the sole layer. The sole layer can be formed by injection molding, compression molding, or other suitable method.

[0010] These and other objects, along with advantages and features of the present invention herein disclosed, will become apparent through reference to the following description, the accompanying drawings, and the claims. Furthermore, it is to be understood that the features of the various embodiments described herein are exemplary only, are not mutually exclusive, and can exist in various combinations and permutations.

Brief Description of the Drawings

[0011] The drawings are not necessarily to scale, emphasis instead generally being placed upon illustrating the principles of the invention. In the following description, various embodiments of the present invention are described with reference to the following drawings, in which:

FIG. 1A is a schematic perspective view of a bottom and side of a sole in accordance with the present invention;

FIG. 1B is a schematic enlarged view of a portion of the sole of **FIG. 1A** taken at **B**;

FIG. 1C is a schematic cross-sectional view of the sole of **FIG. 1A** taken at line **C-C**;

FIG. 2A is a schematic perspective view of the bottom and side of another sole in accordance with the present invention;

FIG. 2B is a schematic cross-sectional view of the sole of **FIG. 2A** taken along line **B-B**;

FIG. 3A is a schematic side view of an article of footwear in accordance with the present invention;

FIG. 3B is a schematic cross-sectional view of the article of footwear of **FIG. 3A** taken along line **B-B**,

FIGS. 4A-4B are a schematic perspective view and a partial enlarged view of another article of footwear in accordance with the present invention;

FIG. 5 is a schematic perspective view of yet another article of footwear in accordance with the present invention;

FIGS. 6A-6I are schematic views of various mesh structures in accordance with the present invention;

FIG. 7 is a schematic side view of a compression mold and mesh in accordance with the present invention; and

FIG. 8 is a schematic side view of a mesh and an injection mold in accordance with the present invention.

Description

[0012] When shoes are designed and constructed, in particular athletic shoes such as running shoes, importance is attached to the weight of the shoe. The weight is determined by the type and the quantity of the materials used. Especially in the case of running shoes which are used for competitions, there is the objective to provide a shoe which is as light as possible but which, at the same time, maintains its essential properties. Examples of such properties are good traction and damping from the sole, as well as precise fit and support of the foot by the upper.

[0013] The invention avoids the use of a conventional, heavy outsole, without sacrificing traction and damping. Since conventional outsoles have a relatively high weight, the total weight of the sole is significantly reduced. According to the invention, the sole is constructed from a light weight cushioning layer having a light weight mesh at least partially embedded in the layer that provides traction for the wearer and abrasion resistance for the sole.

[0014] **FIGS. 1A-1C** depict one embodiment of a sole **120** constructed in accordance with the present invention. The sole **120** generally includes a mesh **130** embedded in a bottom, ground engaging sole layer **140**. The mesh **130** extends along and is substantially coterminous with a bottom surface **142** and, optionally, a front surface **144** of the sole layer **140**. Also shown are a plurality of profile grooves **150** defined by the bottom surface **142** of the sole layer **140** to further improve traction.

[0015] Referring to FIGS. 1B-1C, the mesh 130 has a contoured surface in that it is formed by individual threads 135 that are woven together as opposed to, for example, a flat grid-like structure. The threads 135 are spun from fibers of one or more different materials and then are woven into a contoured knit structure, yarn, or fabric to form the mesh 130. The mesh 130 also can be formed by various methods other than knitting or weaving, for example, by shaping or molding polymeric and/or other materials, to form a contoured or non-planar surface. The threads 135 also can be formed from fibers other than by spinning or weaving, for example, by heat-welding, adhesion, or coextrusion. The mesh 130 also can be constructed directly from fibers, for example, by knitting, weaving, adhering, coextruding, or heat-welding. The mesh 130 extends substantially across the bottom surface 142 and the front surface 144 of the sole layer 140. Optionally, however, the mesh can extend over only portions of the bottom surface 142, for example, the area about the heel and/or over the side of the sole layer 140.

[0016] The mesh 130 is constructed from light weight materials having relatively good abrasion and grip properties. The mesh 130 and the threads 135 can be constructed from polymers, rubber, metals, or combinations of these or other like materials. Suitable polymers include polyesters, polyamides and aramids, for example, poly-paraphenylene terephthalamide. Suitable aramids include KEVLAR® poly-paraphenylene terephthalamide fiber sold by DuPont (France), and TWARON® aramid fibers sold by Akzo Nobel GmbH (Germany). Other suitable polymeric materials include: polyurethanes, such as a thermoplastic polyurethane (TPU); ethylene vinyl acetate (EVA); thermoplastic polyether block amides, such as the PEBAX® brand sold by Elf Atochem; thermoplastic polyester elastomers, such as the HYTREL® brand sold by DuPont; nylons, such as nylon 12 that may include 10 to 30 percent or more glass fiber reinforcement; silicones; polyethylenes; and equivalent materials. The above polymeric materials can be used in combination with other materials, such as rubber or metal. Other suitable materials will be apparent to those skilled in the art.

[0017] The sole layer 140 is constructed from conventional mid-sole materials that are relatively light weight, have relatively good damping properties, and are compliant, yet resilient. Shocks induced by the natural running motion are dampened preferably by the sole layer 140 so that the joints and the muscles of the wearer of the shoe are protected, particularly while running. Suitable damping materials include aerated materials or foams, such as ethylene vinyl acetate (EVA) foam, polyurethane (PU) foam, foam rubber, and combinations of these materials. The

sole layer **140** can also be formed using the energy management system described in German Patent No. 19 914 472 and U.S. Patent No. 4,297,796, incorporated herein by reference. Furthermore, different damping elements known from the prior art can be combined with the sole layer **140** or used in addition to the sole layer **140**, such as gel air cushions, padded inserts or an insole.

[0018] One or more profile or flex grooves **150** can be included in the sole layer **140** to further improve traction and impart flexibility to the sole **120**. The sole layer **140** also can include profile ridges or other known protruding features to improve traction. Traction also can be improved by combining a mesh **130** that is substantially coterminus with the sole layer **140**, as described above in connection with **FIGS. 1A-1C**, with a mesh that extends beyond the bottom ground engaging surface **142** of the sole layer **140**, as described below in connection with **FIGS. 2A-2B**.

[0019] **FIGS. 2A-2B** depict another exemplary embodiment of a sole **220** that generally includes a mesh **230** and a sole layer **240**. Also shown are profile grooves **250** defined by a bottom surface **242** of the sole layer **240**. As shown in **FIG 2B**, the mesh **230** is partially embedded in the sole layer **240** and extends beyond the bottom surface **242** of the sole layer **240**. The mesh **230** is formed from individual threads **235** that are twisted and spun about each other and shaped into a pattern that varies across the bottom surface **242** of the sole **240**.

[0020] The mesh **230** and the sole **240** can be constructed from any of the materials and using any of the methods described above in connection with **FIGS. 1A-1C**. The mesh **230** may be constructed from materials characterized by abrasion resistance, good grip and traction, and low weight, so that projecting portions **234** form a profile on the bottom surface **242** of the sole **220** to provide traction with the ground when in use by a wearer. This also can increase the useful lifetime of the sole **220** because the mesh **230** can be constructed from materials that are abrasion resistant. The mesh **230** contributes to the low weight of the sole **220**, which lessens fatigue caused by the weight of a shoe incorporating the sole **220** when used, for example, while running.

[0021] The mesh **230** can cover all or portions of the bottom surface **242**, front surface **244** or side surface of the sole **220** and be combined with a mesh that is coterminus with the bottom surface **242** of the sole layer **240**. The sole **220** can optionally contain either no profile elements or a variety of profile elements that can be raised or grooved. The soles of the present invention

can also include an additional sole layer, and the mesh can be embedded in this additional layer instead of the cushioning sole layer.

[0022] FIGS. 3A-3B depict an embodiment of an article of footwear or shoe 301 that generally includes an upper 310 attached to a sole 320 that includes a mesh 330 partially embedded in a sole layer 340. As shown in FIG. 3B, the mesh 330 includes embedded portions 332 that are embedded in the sole layer 340, and projecting portions 334 that project from the sole layer 340. The mesh 330 is attached to the sole layer 340 by the embedded portions 332. The projecting portions 334 provide traction during use and resist abrasion of the sole layer 340. The shoe 301 optionally can include an insole 345 and/or a mid sole (not shown).

[0023] The mesh 330 and the sole layer 340 can be constructed from any of the mesh and sole layer materials described above. The mesh 330 may be constructed from materials characterized by abrasion resistance, good grip, and low weight, so that the projecting portions 334 of the mesh 330 form a profile on the bottom surface 342 of the sole 320 to provide traction with the ground when in use by a wearer. This also can increase the useful lifetime of the sole 320, because the mesh 330 is abrasion resistant. The mesh 330 contributes to the low weight of shoe 301, which lessens fatigue caused by the weight of the shoe 301 when used, for example, while running.

[0024] The profile or configuration of the ground engaging bottom surface 342 of the sole 320 can be varied by the size and the shape of the mesh 330. Different profiles also can be realized by varying the kind of spinning used to form the mesh 330, for example, by varying the number and arrangement of burls in the knit and by varying the strength of the knit fabrics. The profile also can be varied by including profile elements such as ridges or grooves.

[0025] The mesh 330 has a non-planar or contoured protruding surface, and is formed by individual fibers 336 that are woven, spun, heat-melded, glued or otherwise attached together, as opposed to, for example, a flat grid-like structure. The mesh 330 can be constructed from knit or woven threads spun from fibers of one or more different materials or constructed from fibers directly. The mesh also can be formed without threads or fibers, for example, by shaping, extruding, gluing, heat-welding or molding polymers, rubber, and/or metals to form the contoured, non-planar surface.

[0026] The upper 310 serves for the accommodation and support of the foot. Conventional materials, construction, and fabrics can be used for the upper 310 to ensure a precise fit. The

upper **310** can consist of light natural or synthetic fibers that are perforated or comprise a loose weave or net for breathability. The upper also can include supporting elements, such as heel supporting elements. The upper **310** can be attached to the sole **320** by conventional methods, for example, by stitching, stapling, tacking, and/or adhesive.

[0027] **FIGS 4A-4B** depict another embodiment of an article of footwear or shoe **401** in accordance with the present invention. The shoe **401** generally includes an upper **410** attached to a sole **420** that includes a mesh **430** embedded in a sole layer **440**. The mesh **430** extends along and is substantially coterminous with a bottom surface **442** of the sole layer **440**. Also shown are profile grooves **450** defined by the bottom surface **442** of the sole layer **440**. The mesh **430** is woven from spun threads **435**.

[0028] The materials and construction and alternative embodiments of the shoe **401**, including the mesh **430**, the sole layer **440**, and the upper **410**, are as described above, for example, in connection with **FIGS 1A-1C**. For example, the mesh **430** can be combined with a mesh that extends from the bottom surface of the sole layer like that described in connection with **FIGS. 2A-2B** and **FIGS. 3A-3B**.

[0029] **FIG. 5** depicts yet another embodiment of an article of footwear or shoe **501**. The shoe **501** generally includes an upper **510** attached to a sole **520** that includes a mesh **530** embedded in a sole layer **540**. The mesh **530** extends along and is substantially coterminous with a bottom surface **542** of the sole layer **540**. Also shown are profile grooves **550** defined by the bottom surface **542** of the sole layer **540**. The mesh **530** is woven from spun threads **135**, as described with respect to **FIGS. 1A-1C**. Shoe **501** avoids the use of a conventional, heavy outsole, without sacrificing good damping, abrasion resistance, and traction properties.

[0030] The materials and construction and alternative embodiments of the shoe **501** including the mesh **530**, the sole layer **540**, and the upper **510**, are as described above, for example, in connection with **FIGS. 1A-1C**. For example, the mesh **530** can be combined with a mesh that extends from the bottom surface of the sole layer like that described in connection with **FIGS. 2A-2B** and **FIGS. 3A-3B**.

[0031] **FIGS. 6A-6I** depict varying mesh configurations in accordance with the present invention. **FIG. 6A** depicts a close knit weave. **FIG. 6B** depicts a loose knit weave. **FIG. 6C** depicts a mesh pattern having a series of substantially parallel threads. **FIG. 6D** depicts a generally spiral mesh. **FIG. 6E** depicts a loose knit weave. **FIG. 6F** depicts a spiral weave

constructed from threads of spun fiber. **FIG. 6G** depicts a two layer cross-hatch. **FIG. 6H** depicts a wave pattern melded on its sides to two threads. **FIG. 6I** depicts a parallel mesh constructed from threads of spun fiber. The elements of the mesh configurations shown in **FIGS. 6A-6I** can be woven, glued, heat-welded or otherwise constructed. The elements also can be formed in a mold, for example, a compression or injection mold having an inner surface configured to the desired contours of the mesh. For example, the spiral configuration of **FIG. 6D** can be formed in this manner. The mesh can be constructed from any of the materials and using any of the methods described above. More than one mesh design can be combined to adapt different portions of the sole profile to different requirements as shown in **FIGS. 2A-2B**. For example, one mesh configuration or design can be used in the heel portion of the sole and another in the forefoot portion of the sole.

[0032] Another aspect of the present invention concerns methods of manufacturing a sole for an article of footwear. The method includes the steps of providing a mold, inserting a mesh into the mold, and forming a sole layer in the mold, the sole layer having a mesh layer at least partially embedded in the sole layer. The mold can be any type of mold, including a compression mold or an injection mold, as described below in **FIG. 7** and **FIG. 8**. The sole, including the mesh and the sole layer, can be constructed from any of the materials and have any of the configurations described above. The mesh can be substantially coterminus and/or project from the bottom surface of the sole layer, as described above.

[0033] **FIG. 7** depicts an embodiment of a compression mold **770** and a mesh **730**. The mold **770** generally includes an inner surface **772** that determines the shape of the sole layer to be formed, and structural features **774** such as depressions that are complementary to the geometry of the mesh **730**. During the molding process, the mesh **730**, that has been inserted into the complementary structural features **774**, is partially embedded in the sole layer as the sole layer is formed in the mold, such that portions of the mesh **730** extend from the bottom surface of the sole layer as described above. The mesh **730** can be positioned and retained in the mold **770** to maintain its desired position during the molding step, for example, by aligning the mesh **730** within the complementary structures **774** or a registration device, such as registration pins.

[0034] The mold also can have additional structural features on the inner surface **772** to form profile ridges and/or grooves as described above. When forming a sole with both coterminus

mesh and mesh that extends beyond the sole layer, the mold 770 might have complementary structures in some portions of the inner surface and not in others.

[0035] The method also can include the step of coating the portions of the mesh that are to extend from the sole layer with a removable film or release agent, so that these portions are selectively prevented from being embedded in the sole layer during the embedding step. This obviates the need for complementary structural features in the mold and allows the mold to be used in forming a variety of soles with different mesh configurations that are partially embedded in the sole layer. This step can also be used to coat only portions of the mesh so that the uncoated portion of the mesh is embedded in the sole layer, and the coated portion is only partially embedded in the sole layer. The method also can include the step of coating portions of the mesh that are to be embedded and/or partially embedded in the sole layer with a bonding agent such as an adhesive or crosslinking agent to improve bonding between the mesh and the sole layer. Use of a release agent would prevent bonding, as known by those skilled in the art.

[0036] After inserting the mesh 730 in the mold 770, a sole slug made of a preferred material of the sole layer is placed in the mold 770. Standard vulcanization methods then can be used to apply heat and force to the sole slug in mold 770 so that the sole material flows in the contours of the inner surface 772 of the mold 770 and bloats. The material of the sole layer also penetrates into the mesh 730 and subsequently cures. After conventional cooling and eventual post-vulcanizing corrections, a form stable, light sole according to the present invention is obtained.

[0037] FIG. 8 depicts an exemplary embodiment of an injection mold 860 and a mesh 830. The injection mold 860 generally includes an inner surface 872 that determines the shape of the sole layer to be formed, and optional structural features 874 that are complementary to the geometry of the mesh 830. During the molding process, the mesh 830 that has been inserted into the complementary structural features 874 is partially embedded in the sole layer as the sole layer is formed in the mold, such that portions of the mesh 830 extend from the bottom surface of the sole layer, as described above. The mesh 830 can be mounted in the injection mold 860 to retain its desired position during the molding step, for example, by aligning it within the complementary structures 874 or with another type of registration device such as registration pins.

[0038] The mold 860 also can have structural features to form profile ridges and/or grooves as described above. When forming a sole with both coterminus mesh and mesh that extends

beyond the sole layer, the mold **860** might have complementary structures in some portions of the inner surface and not in others.

[0039] The method also can include the step of coating the portions of the mesh that are to extend from the sole layer with a removable film or release agent, so that these portions are selectively prevented from being embedded in the sole layer during the embedding step. This obviates the need for complementary structural features and allows the injection mold to be used in forming a variety of soles with different mesh configurations that are partially embedded in the sole layer and/or substantially coterminus with the sole layer. The method also can include the step of coating portions of the mesh that are to be embedded in the sole layer with a bonding agent such as adhesive or crosslinker to improve bonding between the mesh and the sole layer. Use of a release agent would prevent bonding, as known by those skilled in the art.

[0040] After inserting the mesh **830** into the injection mold **872**, the material of the sole layer is injected into the mold **872** and is vulcanized using conventional injection molding methods and techniques so that the sole material flows in the contours of the inner surface **872** of the mold **860** and bloats. The material of the sole layer also penetrates into the mesh **830** and subsequently cures. After conventional cooling and eventual post-vulcanizing corrections, a form stable, light sole according to the present invention is obtained.

[0041] Yet another aspect of the present invention is directed to a method for manufacturing an article of footwear. The method generally includes the steps of: providing a mold; inserting a mesh into the mold; forming a sole layer in the mold, the sole layer having a mesh layer at least partially embedded in the sole layer; and attaching an upper to the sole layer. This method is described above with respect to the method of manufacturing a sole for an article of footwear and includes the further step of attaching an upper to the sole layer. The upper can be attached to the sole by conventional means such as adhesive, stitching, and/or tacking.

[0042] Having described certain embodiments of the invention, it will be apparent to those of ordinary skill in the art that other embodiments incorporating the concepts disclosed herein may be used without departing from the spirit and scope of the invention. The described embodiments are to be considered in all respects as only illustrative and not restrictive.

[0043] What is claimed is: